Conversion electron measurement for the α decay of ^{257}No

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The stability of superheavy nuclei is one of the most interesting subjects in nuclear physics. This stabilization is caused by nuclear shell effects. Many theoretical studies have predicted the shell structure around the superheavy region, while the experimental information is very scarce. In particular, little is known about the level structure, e.g. level energies of excited states, spin-parities and single-particle configurations of the ground state as well as the excited states, and γ transitions between them. The aim of this study is to establish Nilsson single-particle states in odd-mass Z>100 and N>152 nuclei through experimental spin-parity assignments for the ground state as well as excited states by means of α-γ and α-conversion electron spectroscopy. In this presentation, we report our first results on the α decay of ^{257}No.

The nucleus ^{257}No was produced by the ^{248}Cm(^{13}C,4n) reaction at the JAERI tandem accelerator facility. Reaction products recoiling out of the targets were thermalized in He gas loaded with PbI_2 clusters, and transported into a surface ionization-type thermal ion source of the JAERI on-line isotope separator (ISOL) with a gas-jet transport system [1]. Mass-separated ions were implanted into a Si PIN photodiode detector (9 mm x 9 mm x 0.3 mm^t) around which another three photodiodes were placed to detect α particles and electrons simultaneously. Energy calibration of the detectors was performed using a mass-separated ^{221}Fr source implanted into the same Si detector by this ISOL system before and after the on-line experiment, and also using an ^{241}Am source. Energy resolution of the detectors was 2.1 keV (FWHM) for 59 keV γ rays, and about 3.5 keV for 100 keV electrons. Typical γ and electron spectra of ^{241}Am and ^{221}Fr are shown in Fig. 1.

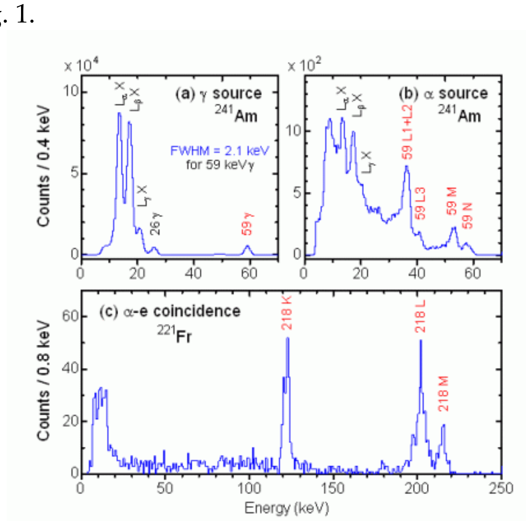

Figure 1. Typical γ and electron spectrameasured by a Si PIN photodiode detector. (a) Gamma-ray spectrum for an ^{241}Am γ source. (b) Gamma and electron spectrum measured using an ^{241}Amα source. (c) Electron spectrum in coincidence with 6126 keV αparticles of ^{221}Fr.

Figures 2(a) and (b) show an α singles spectrum for the mass-257 fraction and an electron spectrum in coincidence with the 7500-8500 keV α particles. As shown in Fig. 2(b), two prominent electron peaks are observed at 50.0 and 97.4 keV, which correspond to the L internal-conversion electrons of the 77.5 and 124.9 keV γ transitions in ^{253}Fm, respectively. The M electron peaks are also observed at 70.4 and 117.6 keV. Taking into account the α-e and e-e coincidence relationships, we have established a newly proposed decay scheme of ^{257}No given in Fig. 3 together with a previously evaluated one [2,3]. It has been revealed that the 8323 keV α transition populates the excited state of ^{253}Fm, not the ground state, and the 8270 keV transition does not exist in the decay scheme; this α peak arises from the coincidence summing effect between the 8222 keV α particles and the 50 keV electrons.

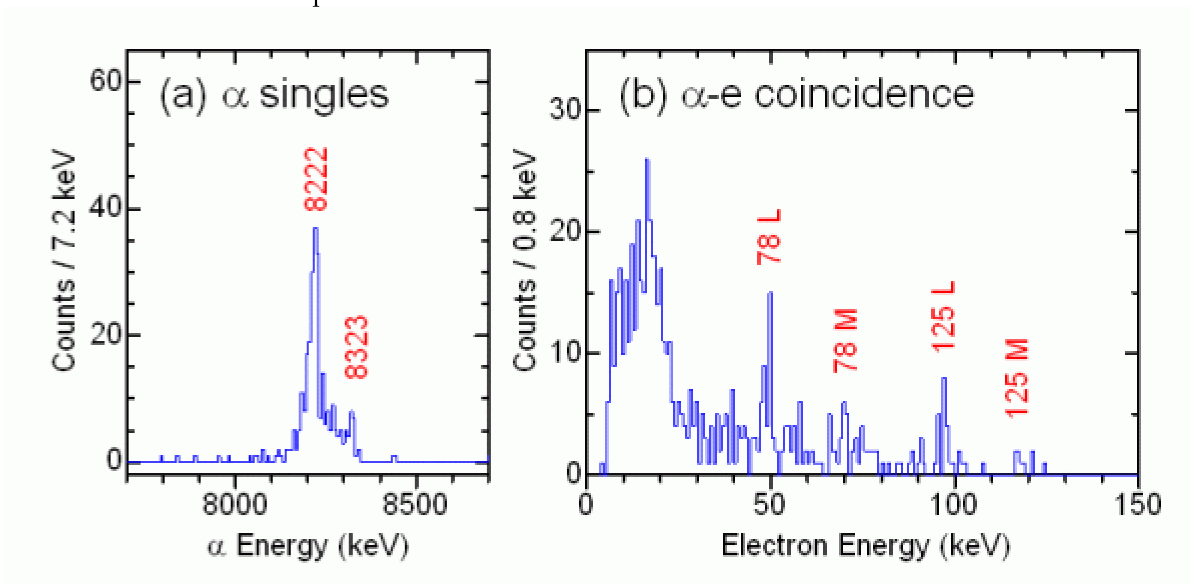

Figure 2. (a) Alpha singles spectrum for ^{257}No measured by a detectorwith a 20% detection efficiency. (b) Electron spectrum in coincidence with 7500-8500 keVα particles of ^{257}No.

Theoretical L internal conversion coefficients (ICCs) of a 125 keV γ transition in Z=100 nuclei (α_{L1}, α_{L2}, α_{L3}) are (0.031, 0.021, 0.015), (0.33, 4.3, 2.3), and (4.0, 0.48, 0.014) for E1, E2, and M1 multipolarities, respectively [4]. The observed electron/α intensity ratio allows us to exclude the E1 assignment for both the 78 and 125 keV transitions owing to small ICCs of E1 transitions. The L3 ICC of E2 transitions is about a half of the L1+L2 ICC, while that of M1 transitions is negligibly small. The observed L electron spectra show no such a large L3 component. Therefore, the M1 multipolarity is assigned to both the 78 and 125 keV transitions. Since the spin-parity of the ground state of ^{253}Fm is $1/2^+$, that of the 125 keV level is either $1/2^+$ or $3/2^+$. The 125 keV level is populated by the allowed α transition with HF=1.3, indicating that the configuration of this level is the same as that of the ground state of ^{257}No. Only the 3/2[622] state could lie at such low energy in ^{253}Fm among the Nilsson single-particle states with a spin $1/2^+$ or $3/2^+$. Thus, we assign the 3/2[622] configuration to the ground state of ^{257}No as well as the 125 keV level in ^{253}Fm. The 24 and 47 keV levels would be the $3/2^+$ and $5/2^+$ members of the 1/2[620] band whose energies are consistent with those in neighboring nuclei.

In conclusion, excited states in ^{253}Fm populated via the α decayof ^{257}No have been established through α-e coincidence spectroscopy. Spin-parities of the ground state of ^{257}No as well as the excited states in ^{253}Fm were determined from the multipolarity of γ transitions and α decay hindrance factors. The 3/2[622] configuration was assigned to the ground state of ^{257}No, which is different from the ground state of other N=155 isotones ^{255}Fm and ^{253}Cf having the 7/2[613] configuration. Next experiment, we will measure α-γ coincidences for the α decay of ^{261}Rf to establish excited states in ^{257}No and assign spin-parities of the ground state of ^{261}Rf as well as the excited states in ^{257}No based on the present spin-parity assignment for the ground state of ^{257}No.

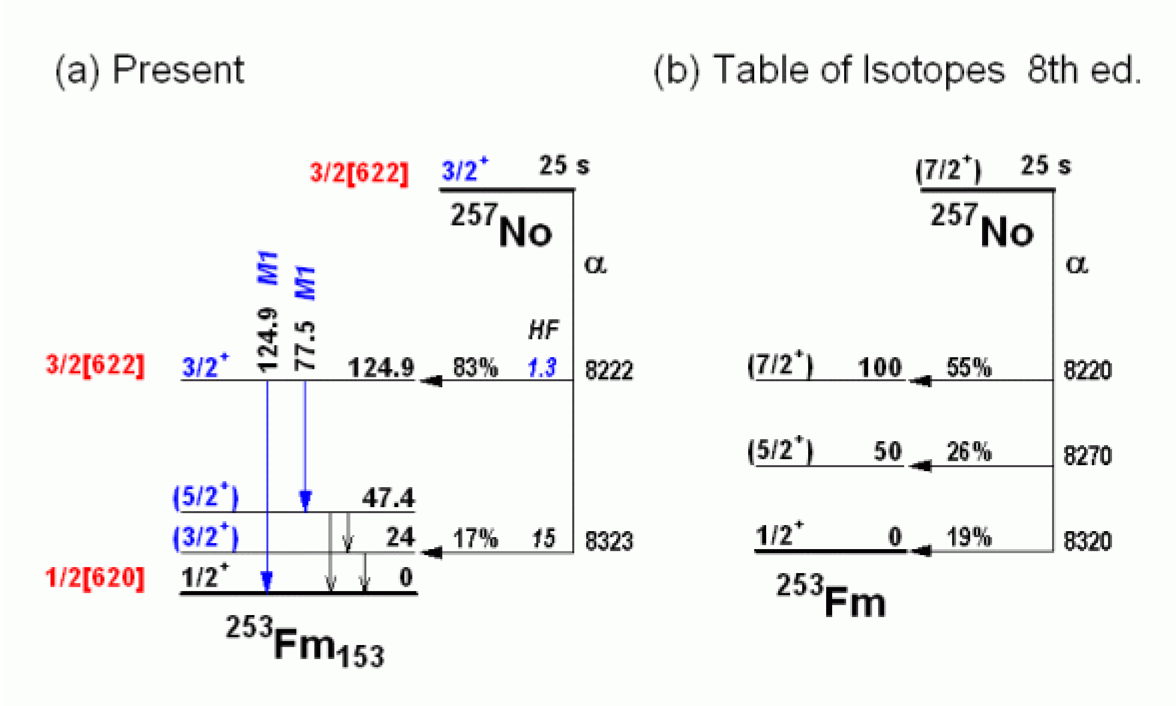

Figure 3. (a) A newly proposed decay scheme of ^{257}No established on the basis of the present experimental result. (b) A previously evaluated one in Refs. [2,3].

References

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